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NATIONAL DAM SAFETY PROGRAM. HALADALE LAKE DAM (MO 30527), MISS--ETC(U)
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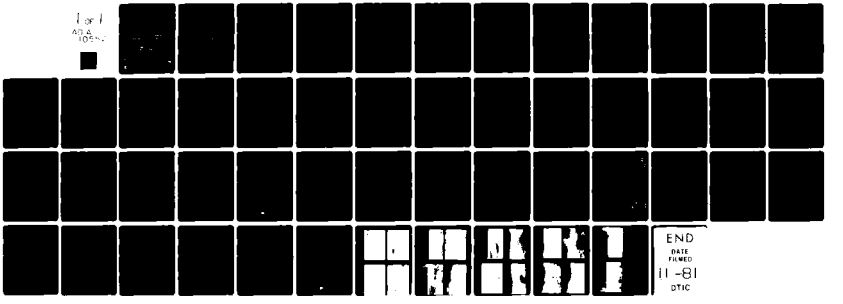

LEVEL II

MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

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HALADALE LAKE DAM

CRAWFORD COUNTY, MISSOURI

MO 30527

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER, 1979

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Dave /Daniels
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[redacted] Nelson /Morales

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: Haladale Lake Dam, MO ID No. 30527

This report presents the results of field inspection and evaluation of the Haladale Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY: SIGNED
Chief, Engineering Division

19 SEP 1979
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

19 SEP 1979
Date

A

HALADALE LAKE DAM

CRAWFORD COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30527

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

September 1979

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Haladale Lake Dam
State Located:	Missouri
County Located:	Crawford
Stream:	Avery Hollow
Date of Inspection:	27 June 1979

Haladale Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately 4 miles downstream of the dam. Located within this zone are three dwellings, one county road and State Highway H. The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 ac-ft but less than 1000 ac-ft.

Our inspection and evaluation indicates that the combined spillways do meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 62 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the small size of the dam, the low impoundment capacity of the reservoir and the large

floodplain downstream, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year frequency flood will not overtop the dam. The 100-year flood is one that has a 1 percent chance of being exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) dense tree and brush growth on the entire embankment; (2) some erosion on the downstream embankment face; (3) lack of wave protection for the upstream face of the dam; (4) considerable seepage along the downstream toe of the dam; (5) erosion at the abutment-dam contacts; (6) numerous small animal holes on downstream face of embankment; (7) lack of non-erodible control sections for the spillways; and (8) nearness of the spillway discharge channels to the embankment toe. Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action in the near future to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Steve Brady, P.E. (AEI)

Dave Daniels, P.E. (HEI)

Tom Beckley, P.E. (AEI)

Nelson Morales, P.E. (HEI)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HALADALE LAKE DAM - ID No. 30527

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Haladale Lake Dam in Crawford County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Haladale Lake Dam is an earth and rock fill structure approximately 38 ft high and 960 ft long at the crest. The appurtenant works consist of earth swale spillways located at each abutment. Sheet 3 of Appendix A shows a plan profile and typical section of the embankment.

B. Location:

The dam is located in the north central part of Crawford County, Missouri on Avery Hollow. The dam and lake are within the Leasburg, Missouri 7.5 minute quadrangle sheet (Section 17, T39N, R3W - latitude 38° 05.66'; longitude 91° 16.54'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 38 ft and a maximum storage capacity of approximately 416 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately 4 miles downstream of the dam. Located within this zone are three dwellings, one county road and State Highway H.

E. Ownership:

The dam is owned by Mr. Leo J. Malone. The owner's address is 46 Frontenac Estates, St. Louis, Missouri 63131.

F. Purpose of Dam:

The dam was constructed primarily for recreational purposes, although some flood protection is also provided.

G. Design and Construction History:

No design information or plans are available. Information from the owner indicates that a dam was originally built at the site in 1954. It is reported that this dam contained old barrels and other miscellaneous debris and did not have any spillways. The dam collapsed in the summer of 1957. Apparently, a development firm named Ronquest reconstructed the dam in 1960. It is reported that earth and blasted rock from the lake area was used to build the existing embankment. No information could be found stating the utilization of a key trench, clay core or internal drainage. The development firm is reported to have gone bankrupt, and the dam changed hands several times. The present owner acquired the property in 1970 after the Missouri Geological Survey prepared a geologic report (Sheet 3, Appendix B).

The owner reported that the seepage at the downstream toe has been active since before he bought the dam. He indicated that the seepage rate has not increased. The only modifications were made in 1978, when both spillways were lowered about 1 ft and the east spillway was widened. Material from the east spillway was used to level a low spot in the

embankment crest. The owner indicated that prior to lowering the east spillway, neither spillway had been used since 1970.

H. Normal Operating Procedures:

All flows will be passed by uncontrolled earth swale spillways located at each abutment (see Sheet 3, Appendix A). The owner indicated that the dam has never overtopped, and that the spillways were first used in 1979, when the water passing over the west spillway was only a few inches deep.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 185 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled, unlined spillways.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 99.5): 874 cfs

(3) Estimated Capacity of Spillway: 874 cfs

(4) Estimated Experienced Maximum Flood at Dam Site: Unknown

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed elevation of 100.0 for the top of the rock outcrop at Station 0+56, 10 ft right of centerline (see Sheet 3, Appendix A).

(1) Top of Dam: 99.5 (Low Point); 100.4 (High Point)

(2) West Spillway Crest: 96.1

(3) East Spillway Crest: 96.3

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam: 62.4

(6) Pool on Date of Inspection: 94.9

(7) Apparent High Water Mark: 96.2

(8) Maximum Tailwater: Unknown

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 1500 ft

(2) At Spillway Crest: 1400 ft

E. Storage Capacities:

(1) At Spillway Crest: 315 acre-ft

(2) At Top of Dam: 416 acre-ft

F. Reservoir Surface Areas:

(1) At Spillway Crest: 28 acres

(2) At Top of Dam: 33 acres

G. Dam:

(1) Type: Earth and Rock Fill

(2) Length at Crest: 960 ft

(3) Height: 38 ft

(4) Top Width: 11 ft

(5) Side Slopes: Upstream 2.6H:1.0V (crest to water level); Downstream Irregular (See Sheet 3, Appendix A)

(6) Zoning: Apparently Homogeneous

(7) Impervious Core: Unknown

(8) Cutoff: Unknown

(9) Grout Curtain: Unknown

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 West Spillway:

(1) Location: West Abutment

(2) Type: Earth swale

I.2 East Spillway:

(1) Location: East abutment

(2) Type: Earth swale

J. Regulating Outlets:

There are no regulating or dewatering facilities associated with this dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data exist for this dam. No documentation of construction inspection records has been obtained. To our knowledge, there are no documented maintenance data.

A. Surveys:

No information regarding pre-construction surveys was obtained. Sheet 3 of Appendix A presents a plan, profile and cross section of the dam from survey data obtained during the site inspection. The top of the rock outcrop at Station 0+56, 10 ft right of centerline, was used as a site datum of assumed elevation 100.00 (see Sheet 3, Appendix A). It is estimated that this site datum approximately corresponds to mean sea level elevation 915.

B. Geology and Subsurface Materials:

The site is located in the north central portion of the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus and deep valleys. The most common rock types are dolomite, sandstone and chert. Information supplied by the Missouri Geological Survey indicates that the lake area is underlain by the Roubidoux formation of the Canadian Series in the Ordovician System. The Roubidoux formation consists of sandstone, dolomitic sandstone and cherty dolomite. The publication "Caves of Missouri" lists a total of seven caves known to exist in Crawford County. All but one of these caves are clustered in a nine square mile area about 5 miles southeast of the site.

The "Geologic Map of Missouri" indicates a normal fault passing near the site in a northwest-southeast direction. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years (rock associated with the Ordovician Period - 500 million years old).

Soils in the area of the dam site appear to be primarily thin deposits of residual silty clays with rock fragments. The soils are of the Clarksville-Fullerton-Talbott Soil Association and have developed from thin

loessial soils deposited over weathered material from cherty dolomites. The loessial thickness map indicates that upland areas may have between 2.5 and 5.0 ft of loess cover.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. There is apparently no particular zoning of the embankment, and no internal drainage features are known to exist. No construction inspection test results have been obtained.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for Haladale Lake Dam were available. Based on a field check of spillway dimensions and embankment elevations, and a check of the drainage area on the U.S.G.S. quad sheet, hydrologic analyses using U. S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 7. It was concluded that the structure will pass 62 percent of the Probable Maximum Flood without overtopping. The 100-year frequency flood will not overtop the dam.

E. Structure:

There are no appurtenant structures associated with this dam.

2.2 CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION AND MAINTENANCE:

Normal flows are passed by uncontrolled earth swale spillways located at each end of the dam. There are no regulating facilities associated with this dam, and therefore, no operating records are known to exist. The dense tree and brush growth on the downstream portion of the embankment indicates that the dam has not been maintained regularly. Some painted tree stumps were evident on the upstream face.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on June 27, 1979. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Gene Wertepny - Hanson Engineers, Inc. (Hydraulic Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)

B. Dam:

The dam appears to be in generally fair condition. The abundant tree and brush growth made it very difficult to inspect the downstream face of the dam (see Photo No. 6). The vertical and horizontal alignments of the crest appeared good, and no surface cracking or unusual movement was obvious. Some erosion was noted on the downstream embankment face. Significant seepage was observed all along the downstream toe of the dam (see Photo No's. 8 & 9). The total seepage was estimated to be about 30 gallons per minute. Numerous small animal holes are present along the downstream face. No erosion protection is provided for the upstream embankment face. The discharge channels of the spillways are very near to the abutment-dam contacts and the downstream toe. Shallow auger probes into the embankment indicated the dam to consist of a reddish brown cherty, silty clay. The owner indicated that materials for construction were obtained from the lake area. Apparently, some blasting was performed, and some rock was used in constructing the dam. No instrumentation (monuments, piezometers, etc.) was observed.

C. Appurtenant Structures:

C.1 West Spillway:

The approach channel to the west spillway is relatively clear of obstructions (see Photo No. 11). No non-erodible control section is provided for the spillway. Significant erosional damage has occurred in the west spillway outlet channel fairly near to the dam-abutment contact (see Photo No. 13).

C.2 East Spillway:

The east spillway approach channel is fairly clear (see Photo No. 15). A non-erodible control section is not provided for this spillway. The outlet channel is near the abutment-dam contact.

D. Reservoir:

The watershed is generally wooded, with no agricultural activity. The slopes adjacent to the lake are moderate, and no sloughing or erosion was noted.

E. Downstream Channel:

The downstream channels of the two spillways are heavily overgrown with trees and brush in the area of the creek. Significant erosional damage has occurred very close to the dam in the west spillway outlet channel.

3.2 EVALUATION:

Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. There is no wave protection provided for the upstream face of the embankment. Non-erodible control sections are not provided for the spillways; therefore, progressive erosion could lower the elevations of the spillways, and thus lower the normal pool elevation of the reservoir. The spillway outlet channels are very near to the downstream embankment face. The erosional areas at the abutment-dam contacts and the small animal holes and erosion on the downstream face of the dam could worsen and adversely affect the stability of the dam. The seepage at the downstream toe of the dam should be investigated by an engineer experienced in the design and construction of dams. The brush and tree growth in the spillway outlet channels can restrict flood flows.

All of these deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no controlled outlet works for this dam. The spillways are uncontrolled, so that the pool is normally controlled by rainfall, runoff, seepage, and evaporation.

4.2 MAINTENANCE OF DAM:

The dense tree and brush growth on the embankment indicates that the dam has not been well maintained. The owner indicated that he has attempted to clear the vegetation several times since he has owned the dam (1970). Some painted tree stumps were noted on the upstream face.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities for this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The seepage areas along the downstream toe of the dam, trees and brush on the dam, erosional areas and animal holes on the downstream embankment face, lack of erosion protection for the upstream face of the dam, lack of non-erodible control sections for the spillways, and the close proximity of the spillway outlet channels to the abutment-dam contacts are serious deficiencies which should be corrected. To avoid creating an unsafe condition, this should be done under the direction of an experienced engineer.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. & B. Design and Experience Data:

The hydraulic and hydrologic analyses were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the pool and drainage areas from the U.S.G.S. quad sheet. Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

Non-erodible control sections are not provided for the spillways. The spillway outlet channels contain brush and trees. The west spillway channel is badly eroded. The spillway outlet channels are very near to the dam.

D. Overtopping Potential:

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 62 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the small size of the dam, the low storage impoundment capacity of the reservoir and the large floodplain downstream, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The structure will pass a 100-year frequency flood without overtopping.

The routing of 50 percent of the PMF through the spillways and dam indicates that the dam will not be overtopped. The maximum discharge capacity of the spillways is 874 cfs. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Physical factors observed which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The only reported post-construction change was in 1978 when spillways were lowered and the east spillway was widened. At that time, a low area on the crest of the dam (east side-see Photo No. 2) was raised.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in fair condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) dense tree and brush growth on downstream face of the dam; (2) considerable seepage along downstream toe of the embankment; (3) lack of wave erosion protection for the upstream embankment face; (4) some erosion and numerous animal holes on the downstream face of the dam; (5) lack of non-erodible control sections for the spillways; (6) significant erosion in the west spillway channel near the abutment-dam contact; and (7) the nearness of the spillway discharge channels to the downstream embankment toe.

Another deficiency was the lack of seepage and stability analysis records.

The dam will be overtopped by flows in excess of 62 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by the owner and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. Priority should be given to the seepage problem, diverting the spillway outlet channels away from the embankment, and providing non-erodible control sections for the spillways.

D. Necessity for Phase II:

Based on the result of the Phase I inspection, no Phase II inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

(1) Non-erodible control sections should be provided for the spillways so that progressive erosion of the spillway will not lower the normal pool of the reservoir.

(2) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(3) The seepage at the downstream toe of the dam should be investigated by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, this seepage should be channelized and monitored to determine if there is any increase in quantities and whether soil particles are being carried with the water.

(4) Brush and tree growth should be removed from the dam and from the spillway outlet channels. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam. Brush and tree growth should then be removed from the dam on an annual basis.

(5) Wave erosion protection should be provided for the upstream face of the embankment.

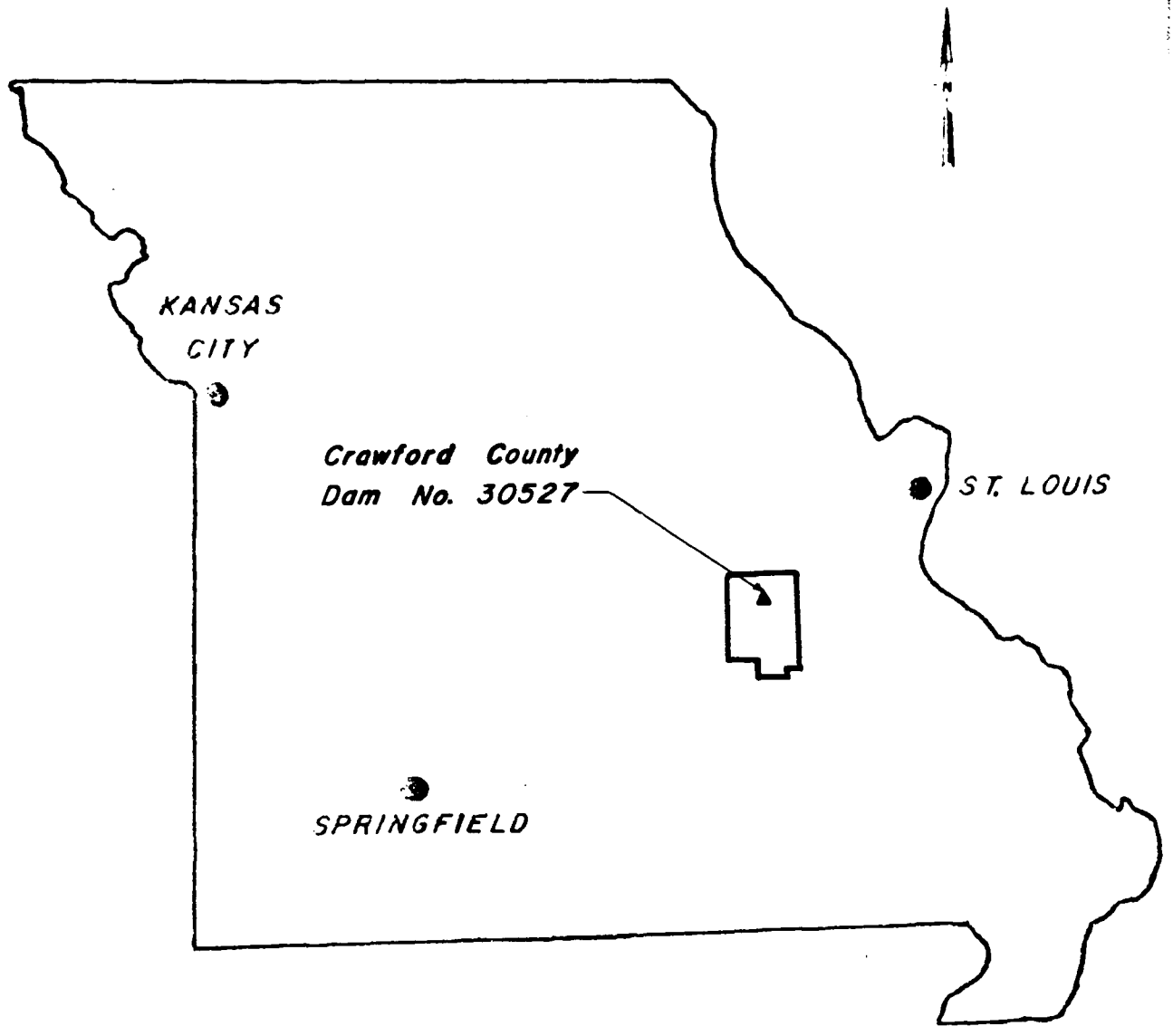
(6) The erosion and animal holes on the downstream face of the dam should be repaired and maintained.

(7) The erosion at the abutment-dam contacts should be corrected and maintained.

(8) The discharges from the spillways should be diverted away from the toe of the dam.

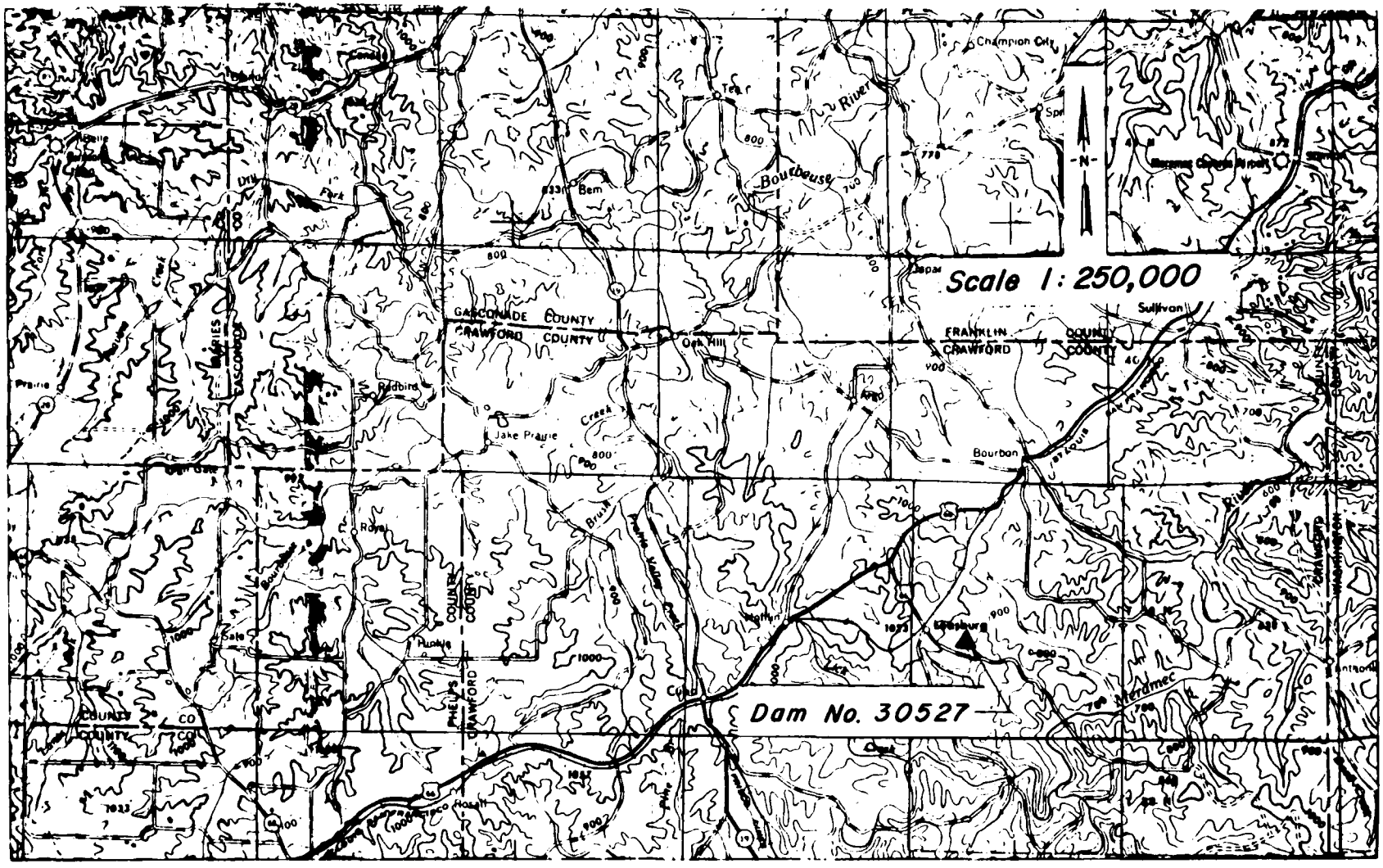
(9) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A



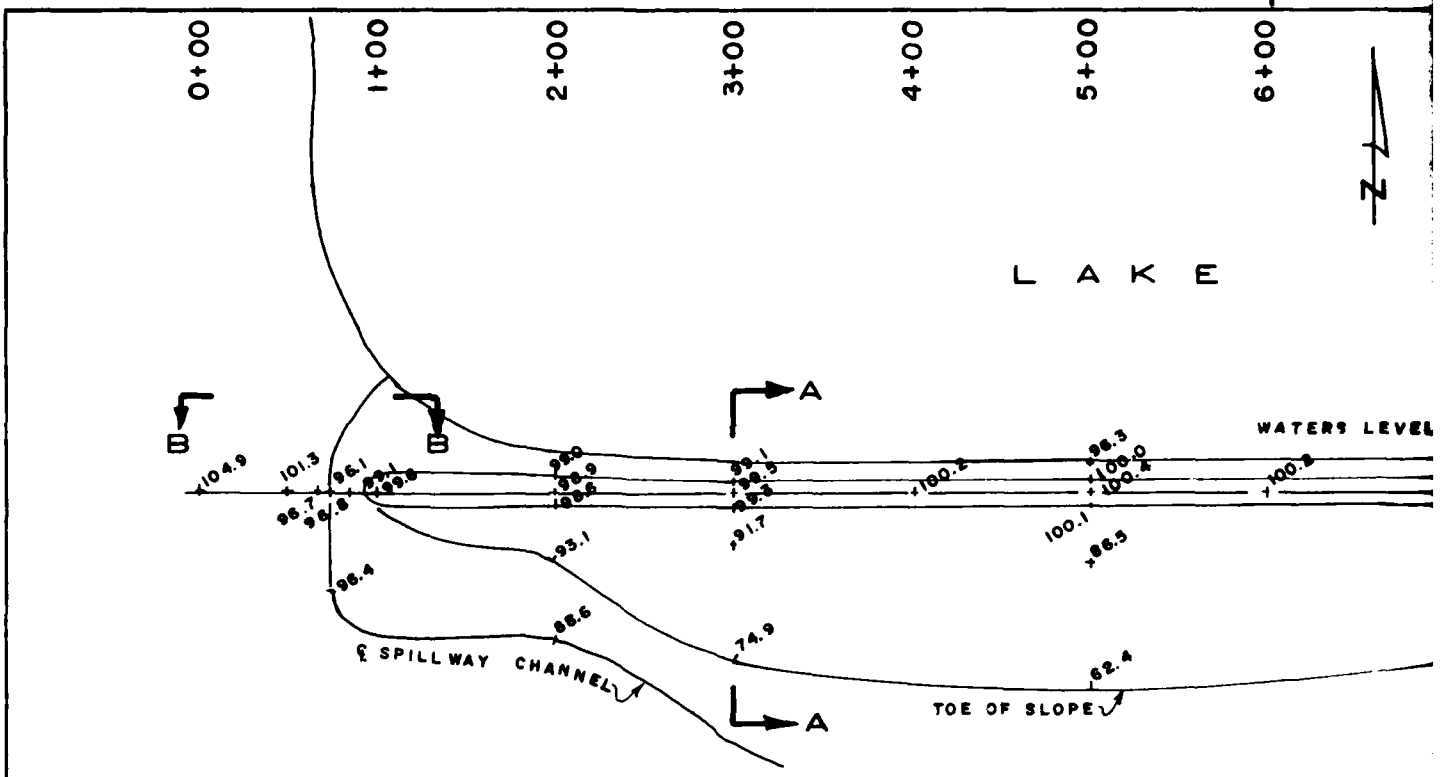
LOCATION MAP

SHEET 1 OF APPENDIX A



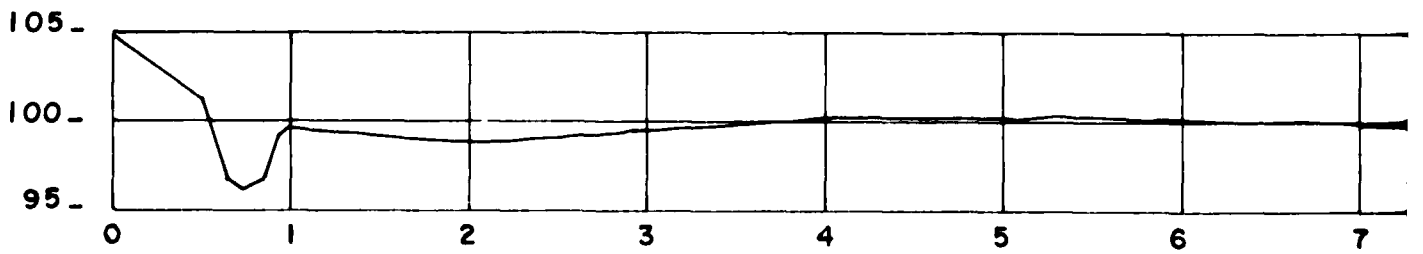
SITE VICINITY MAP

Sheet 2 Appendix A

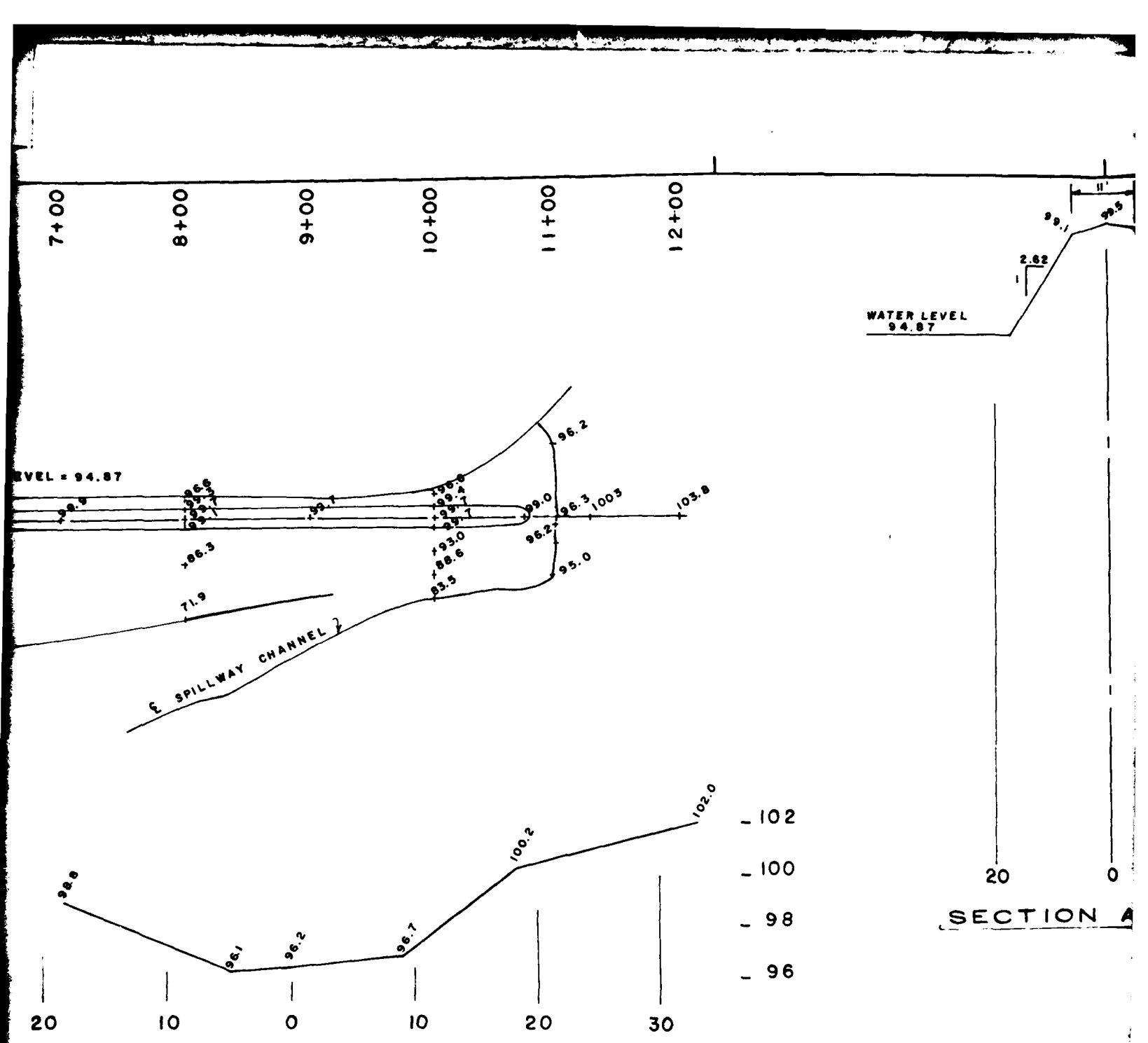


BENCHMARK:
STA 0+56 10' RIGHT OF
℄ TOP OF ROCK OUTCROP
ELEV. 100.00 (Estimated M.S.L. Elev. ±915)

PLAN VIEW
SCALE: 1" = 100'

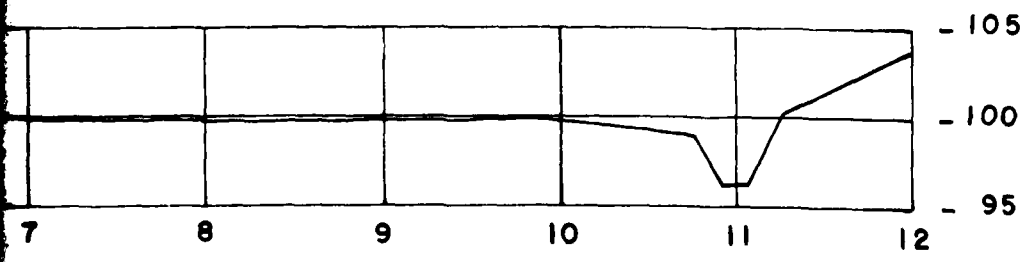


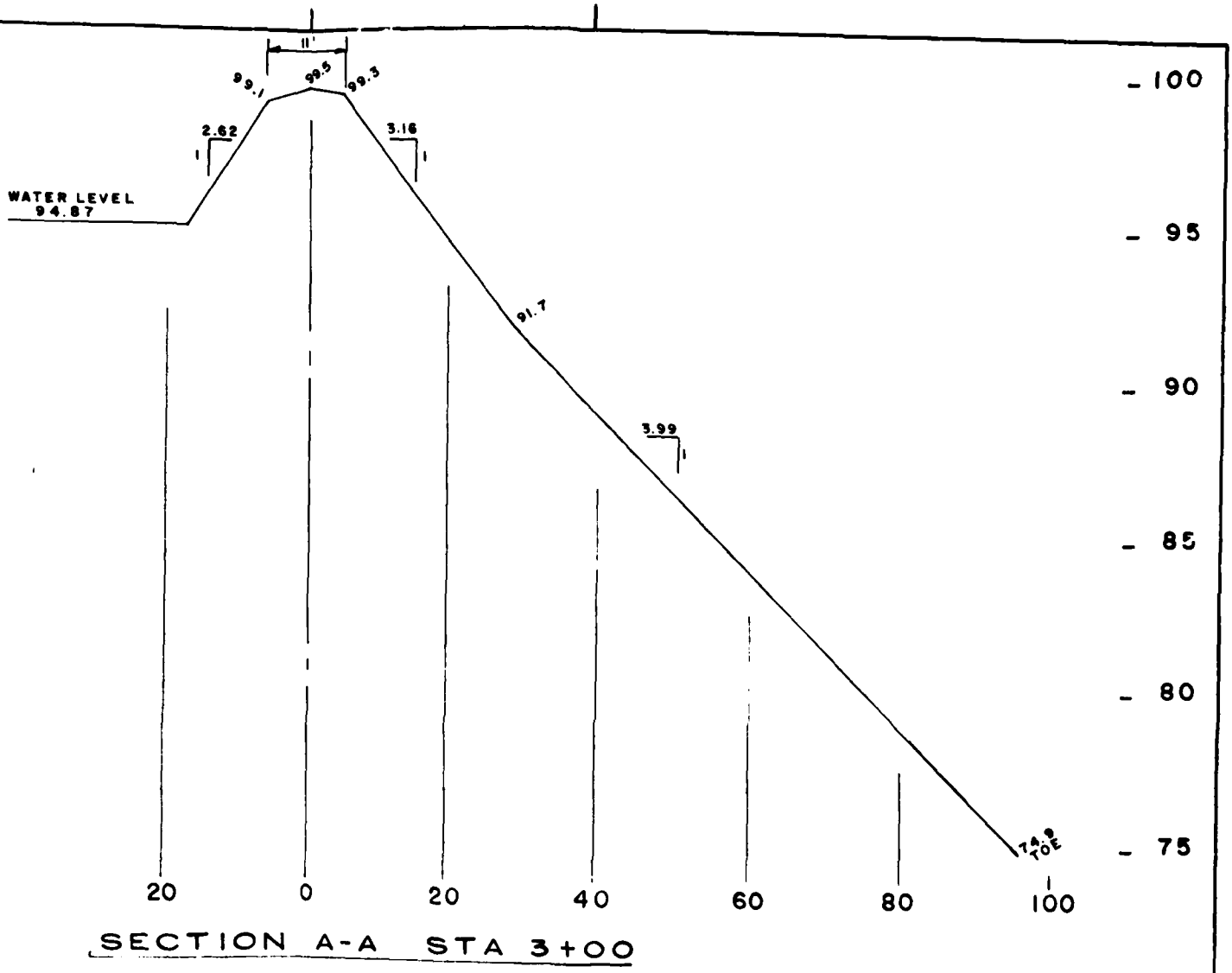
PROFILE



SECTION A

SECTION B-B 23' LT. STA 0-76





SECTION A-A STA 3+00

02
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98
96

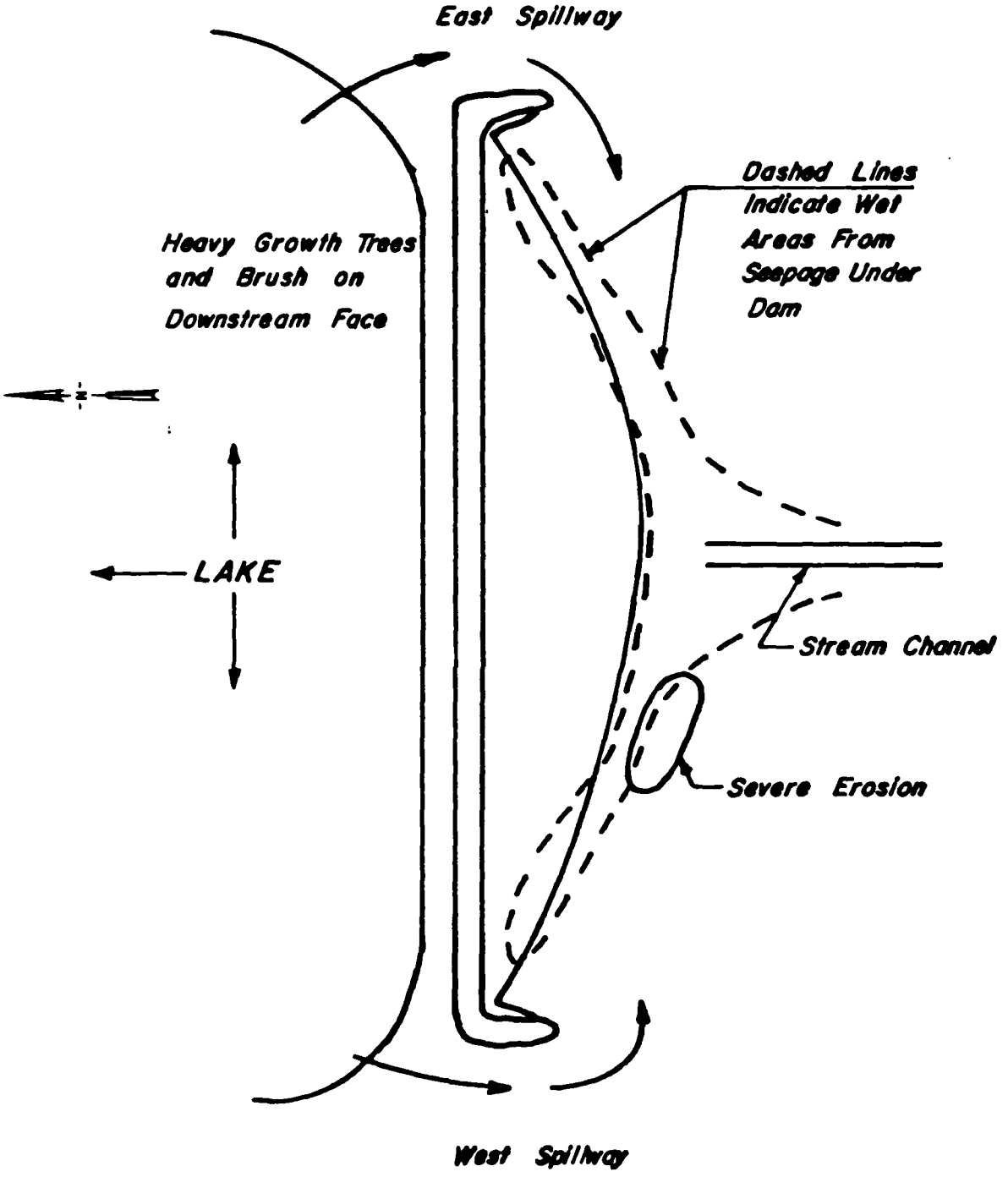
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

HALADALE LAKE

MO. No. 30527

PLAN & PROFILE

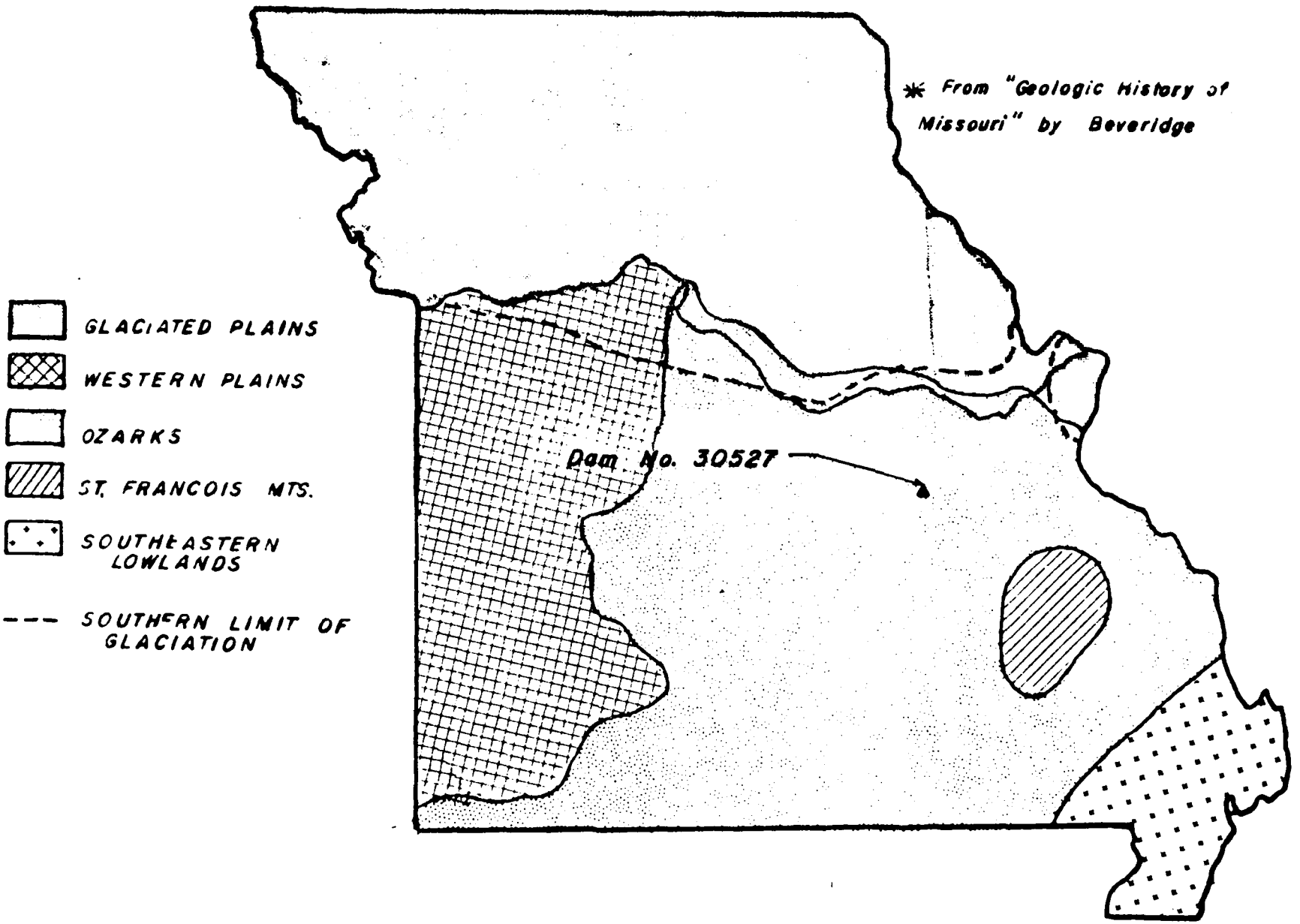
CRAWFORD COUNTY, MO.



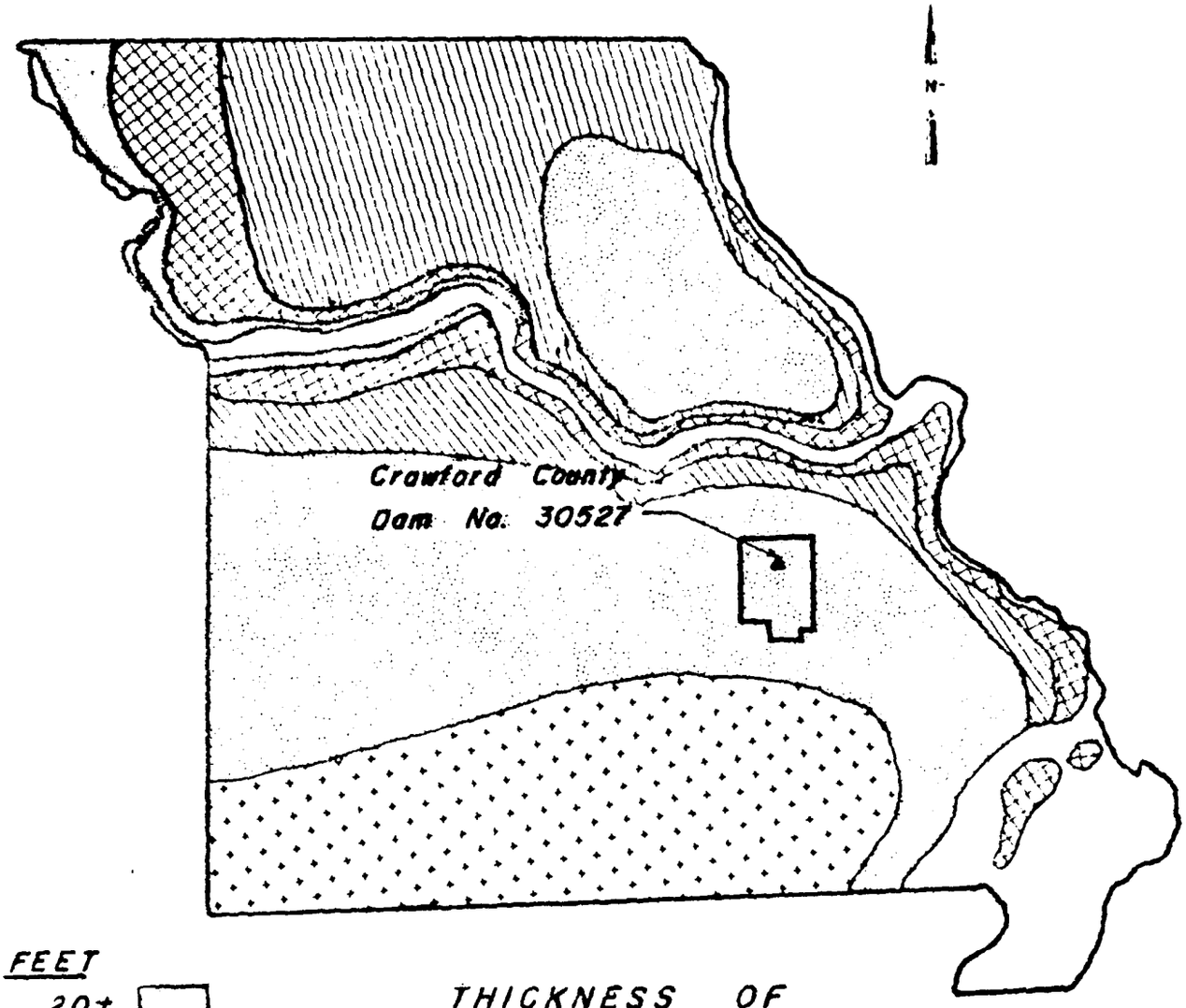
DRAWN DER CHECKED DED DATE 7-20-79 JOB NO. 79611	HANSON ENGINEERS SPRINGFIELD ILL. PEORIA ILL.	Plan Sketch Inspection Observations Sheet 4 Appendix A

APPENDIX B

MAJOR GEOLOGIC REGIONS OF MISSOURI



* From "Soils of Missouri"



FEET

20+

10-20

5-10

2.5-5

2.5-

THICKNESS OF LOESSIAL DEPOSITS

SHEET 2 OF APPENDIX B

GEOLOGIC REPORT ON THE MALONE LAKE, CRAWFORD COUNTY

LOCATION: SE¼ SE¼ SW¼ sec. 17, T. 39 N., R. 3 W., Leasburg Quadrangle

GEOLOGIC SETTING:

The lake is underlain by the Roubidoux Formation, an interlayered sandstone and dolomite. In this area the Roubidoux has been weathered into a soil mixture of sandstone and chert fragments mixed with sandy clay.

Lake and Dam:

The lake with approximately 30 surface acres is supplied by drainage from a moderately sloping timber and grass watershed of 130 acres. The dam is about 37 feet in height and has 2 to 1 slopes. The right abutment spillway is about 20 feet wide and 3 feet below the dam crest. The left abutment spillway, which has not been used, is approximately 2 feet below the crest of the dam. These measurements are based on map and field reconnaissance and are not precise.

Physical Condition of the Dam and Spillway:

Significant seepage occurs at the base of the dam on the downstream valley slopes and in the floodplain. This is probably due to an inadequate core trench. However the seepage will not cause structural failure or serious water loss. Trees on the dam should be cut. The spillway is inadequate and will continue to deteriorate. The spillway on the right abutment should be widened and flattened. A rooted grass should be established. The water from the spillway should not be routed along the downstream toe of the dam. If possible a principal spillway, probably an inclined corrugated metal pipe, should be constructed to maintain a permanent pool level 5 to 6 feet below the crest of the dam. Specific dimensions should be obtained from an engineer familiar with dam construction. The Soil Conservation Service also has data on spillway design.

James H. Williams
Geologist and Chief
Engineering Geology
Missouri Geological Survey
10 August 1970

copy to: Leo Malone
11131 Oak Lake Court
St. Louis 63141

APPENDIX C

From Leasburg 7.5' Quad

LAKE AND WATERSHED MAP

Sheet 1 Appendix C

HYDRAULIC AND HYDROLOGIC DATA

Design Data: From Field Measurements and Computations

Experience Data: No records are available. On the day of inspection, there was no indication of overtopping. Significant erosion was found on the outlet channel of the west abutment spillway. There was no indication that the east abutment spillway has operated. A high water mark at elevation 96.2 was found.

Visual Inspection: At the time of the inspection, the pool level was approximately 1.33 ft below normal pool.

Overtopping Potential: Flood routings were performed to determine the overtopping potential. The watershed and the reservoir surface areas were obtained by planimeter from the U.S.G.S. Leasburg, Missouri 7.5 minute quadrangle map. The storage volume was developed from these data. A 5 minute interval unit graph was developed for this watershed, which resulted in a peak inflow of 1170 c.f.s. and a time to peak of 7 minutes. Application of the probable maximum precipitation minus losses results in a flood hydrograph peak inflow of 4281 c.f.s. Rainfall distribution for the 24 hour storm was according to EM 1110-2-1411.

Based on our analyses, the combined spillways will pass 62 percent of the Probable Maximum Flood (PMF). The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that the structure (small size with high downstream hazard potential) pass 50 to 100 percent of the PMF, without overtopping. Considering the size of the dam, the small storage volume and the large floodplain downstream with minor development, 50 percent of the PMF has been determined to be the appropriate spillway design flood.

The routing of 50 percent of the PMF through the spillway and dam indicates that the dam will not be overtopped. The maximum discharge capacity of the combined spillways is 874 c.f.s. Analysis of the data indicates that the 100-year frequency flood will not overtop the dam. The computer input, output and hydrographs for 50 percent of the PMF are presented on Sheets 5, 6 and 7 of Appendix C.

OVERTOPPING ANALYSES FOR HALADALE LAKE DAM

INPUT PARAMETERS

1. Unit Hydrograph - SCS Dimensionless - Flood Hydrograph Package (HEC-1); Dam Safety Version Was Used.
   Hydraulic Inputs Are As Follows:

   a. Twenty-four Hour Rainfall of 25.8 Inches For 200 Square Miles - All Season Envelope

   b. Drainage Area = 185 Acres; = 0.29 Sq. Miles

   c. Travel Time of Runoff 0.14 Hrs.; Lag Time 0.08 Hrs.

   d. Soil Conservation Service Soil Group B

   e. Soil Conservation Service Runoff Curve No. 78 (AMC III)
      No. 60 (AMC II)

   f. Proportion of Drainage Basin Impervious 0.15

2. Spillways

   a. Right Abutment Spillway: Trapezoidal Earth Cut; Length 18 ft; Side Slopes Vary; C = 2.65

   b. Left Abutment Spillway: Trapezoidal Earth Cut
      Length 14 Ft.; Side Slopes 5:1 7:1; C = 2.65

   c. Dam Overflow

      Length 960 Ft.; Crest El. 99.5 ; C = 3.0

3. Spillway and Dam Rating:

   Curve Prepared by Hanson Engineers. Data Provided To Computer on Y4 and Y5 Cards. (Sheet 5, Appendix C)
   Formula Used: Spillways and Dam $Q = CLH^{1.5}$

Note: Time of Concentration From Equation $Tc = \left(\frac{11.9\ L^3}{H}\right)^{.385}$

California Culvert Practice, California Highways and Public Works, Sept. 1942.

SUMMARY OF DAM SAFETY ANALYSIS

1. Unit Hydrograph

   a. Peak - 1170 c.f.s.

   b. Time to Peak 7 Min.

2. Flood Routings Were Computed by the Modified Puls Method

   a. Peak Inflow

      50% PMF 2140 c.f.s.; 100% PMF 4281 c.f.s.

   b. Peak Elevation

      50% PMF 99.17 100% PMF 100.25

   c. Portion of PMF That Will Reach Top of Dam

      62 %; Top of Dam Elev. 99.5 Ft.

3. Computer Input and Output Data are shown on Sheets 5 and 6 of this Appendix.

```
A       OVERTOPPING ANALYSIS FOR HALADALE DAM ( # 19 )
A       STATE ID NO. 30527  CO. NO. 055  CO. NAME CRAWFORD
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 79511
B    300                5
B1     5
J      1       7       1
J1   .15     .20     .30     .40     .50     .75     1.0
K      0       1                               3       1
K1      INFLOW HYDROGRAPH COMPUTATION
M      1       2    0.29            0.29       1                       1
P      0    25.8     102     120     130
T                                                   -1      -78             0.15
W2  0.14    0.08
X      0    -.1        2
K      1       2                       0       4       1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE
Y                               1       1
Y1     1                                                    315      -1
Y4  96.2      97      98      99    99.5     100     101     102
Y5     0      57     266     633     874    1168    1895    2813
$A     0      28      33      37
$E  62.4    96.2    99.5     102
$$  96.2
$D  99.5     3.0     1.5     960
K     99
```

P.M.F. INPUT DATA

SHEET 5 APPENDIX C

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

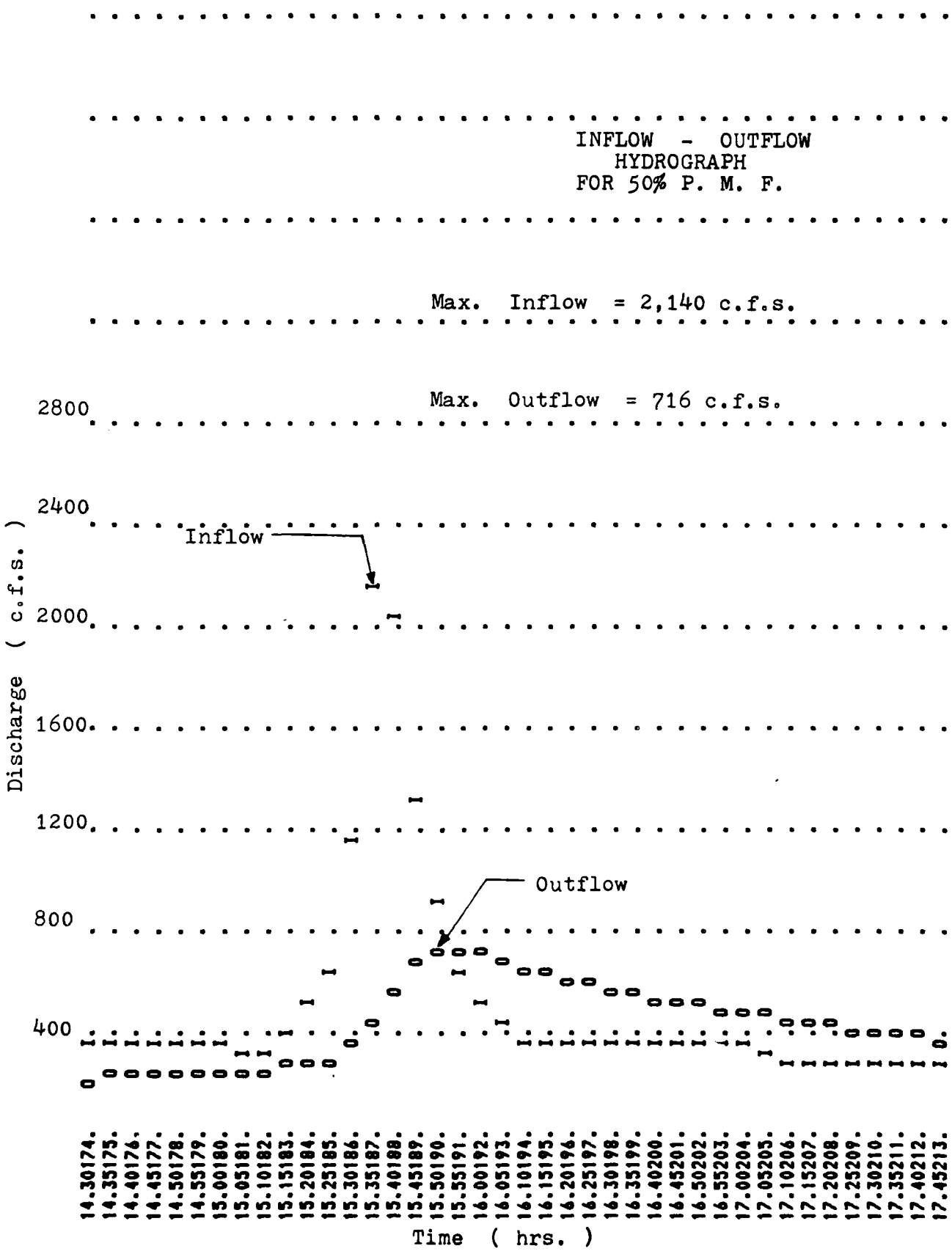
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7
				0.15	0.20	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	0.29	1	642.	856.	1284.	1712.	2140.	3211.	4281.
	(	0.75)	(	18.18)(	24.24)(	36.36)(	48.49)(	60.61)(	90.91)(	121.22)(
ROUTED TO	2	0.29	1	137.	205.	359.	534.	716.	1786.	3199.
	(	0.75)	(	3.88)(	5.80)(	10.16)(	15.11)(	20.28)(	50.57)(	90.59)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	96.15	96.20	99.50
STORAGE	314.	315.	416.
OUTFLOW	0.	0.	874.

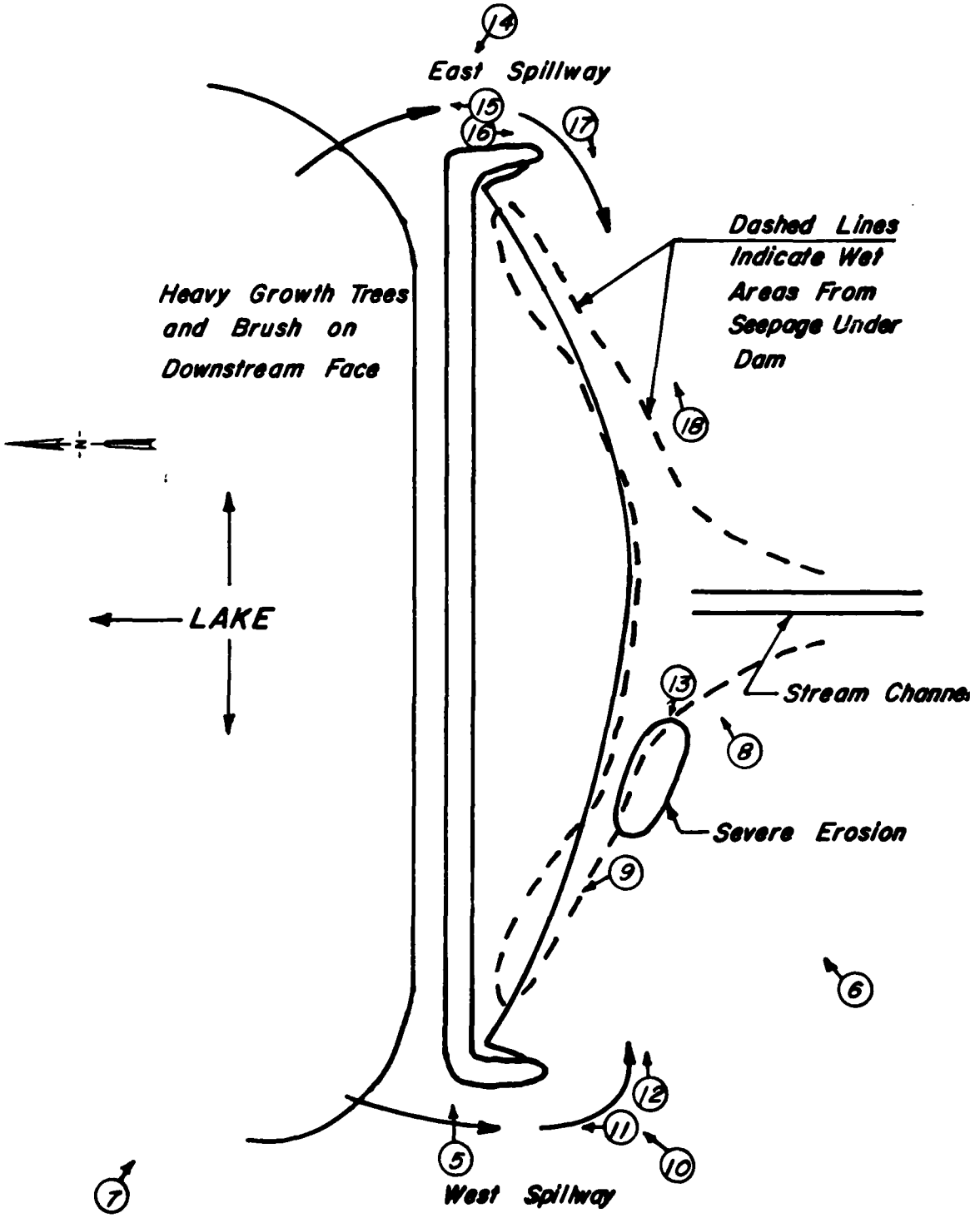
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.15	97.38	0.00	350.	137.	0.00	16.08	0.00
0.20	97.71	0.00	359.	205.	0.00	16.00	0.00
0.30	98.25	0.00	376.	359.	0.00	15.92	0.00
0.40	98.73	0.00	391.	534.	0.00	15.92	0.00
0.50	99.17	0.00	405.	716.	0.00	15.92	0.00
0.75	99.88	0.38	429.	1786.	0.58	15.75	0.00
1.00	100.25	0.75	441.	3199.	0.83	15.75	0.00


INFLOW - OUTFLOW
HYDROGRAPH
FOR 50% P. M. F.
Max. Inflow = 2,140 c.f.s.
Max. Outflow = 716 c.f.s.
Inflow
Outflow
Discharge (c.f.s.)
2800
2400
2000
1600
1200
800
400
14.30174.
14.35175.
14.40176.
14.45177.
14.50178.
14.55179.
15.00180.
15.05181.
15.10182.
15.15183.
15.20184.
15.25185.
15.30186.
15.35187.
15.40188.
15.45189.
15.50190.
15.55191.
16.00192.
16.05193.
16.10194.
16.15195.
16.20196.
16.25197.
16.30198.
16.35199.
16.40200.
16.45201.
16.50202.
16.55203.
17.00204.
17.05205.
17.10206.
17.15207.
17.20208.
17.25209.
17.30210.
17.35211.
17.40212.
17.45213.
Time (hrs.)

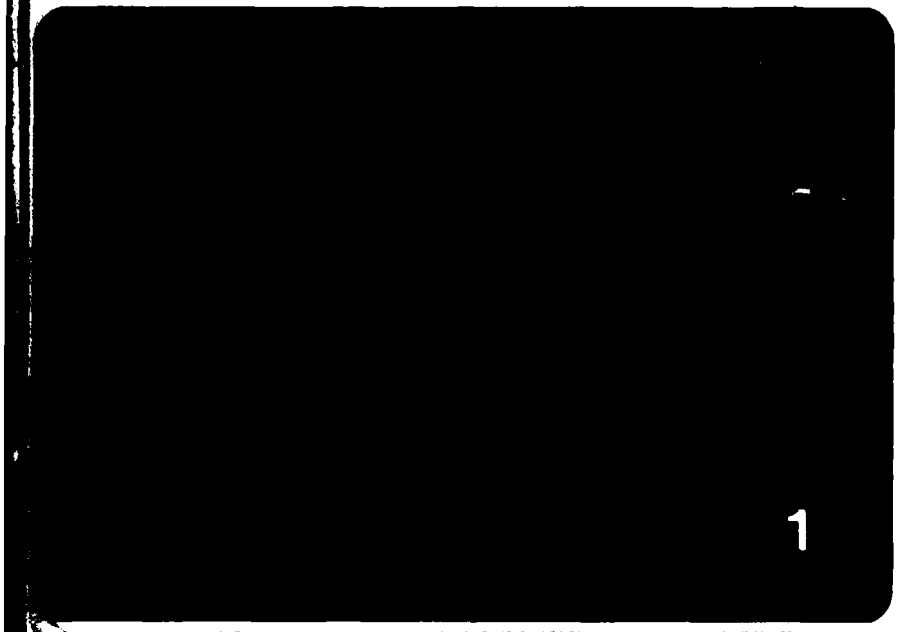
APPENDIX D

INDEX TO PHOTOGRAPHS

Photo No.	Description
1.	Aerial - Lake and Watershed, Looking Southwest
2.	Aerial - Dam and Lake, Looking Northwest
3.	Aerial - Dam, Looking Northwest
4.	Aerial - Dam, Looking East
5.	Crest of Dam, Looking East, West Spillway in Foreground
6.	Downstream Face, Looking Northeast
7.	Upstream Face, Looking Southeast
8.	Downstream Toe Near Center, Note Reeds
9.	Seepage at Downstream Toe, West Side
10.	West Abutment Spillway, Looking Northeast
11.	West Abutment Spillway, Looking Upstream
12.	West Abutment Spillway, Looking Downstream (East)
13.	West Abutment Spillway, Note Erosion
14.	East Abutment Spillway
15.	East Abutment Spillway, Looking Upstream
16.	East Abutment Spillway, Looking Downstream
17.	East Abutment Spillway, Looking Downstream (West)
18.	East Abutment Spillway, Looking Upstream (East)



DRAWN DER CHECKED DED DATE 7-20-79 JOB NO. 79511	HANSON ENGINEERS SPRINGFIELD ILL. PEORIA ILL.	Plan Sketch Key To Photographs Sheet 2 Appendix D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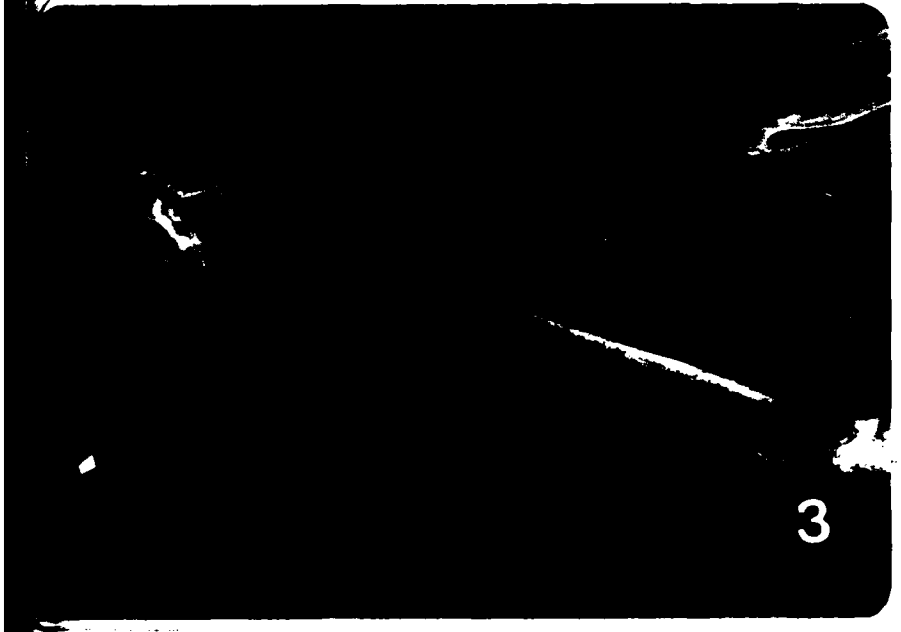
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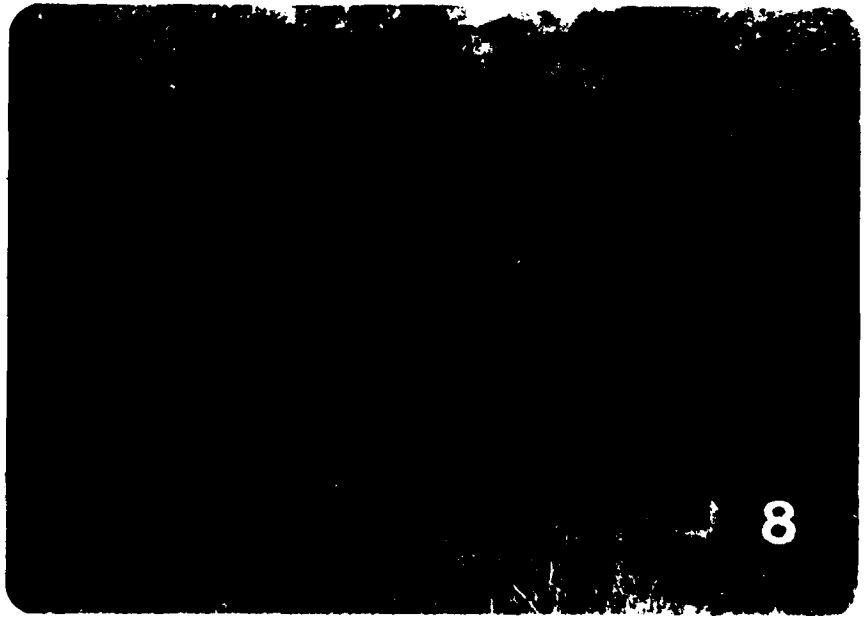
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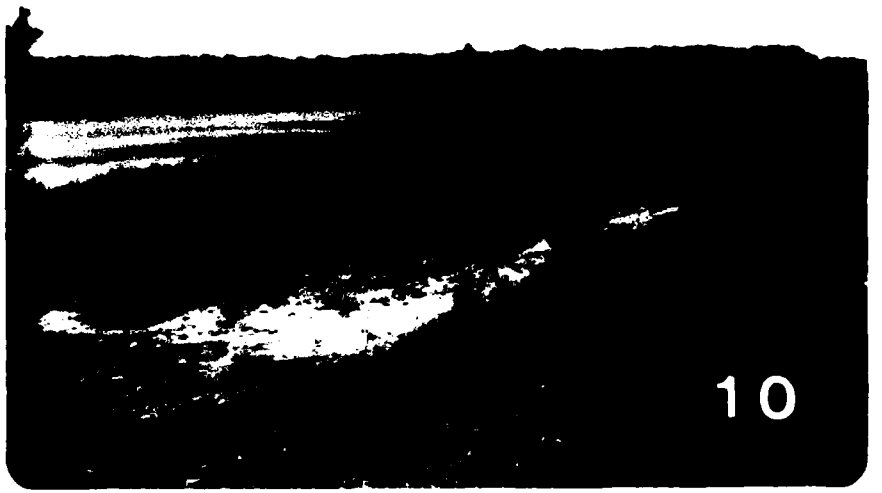
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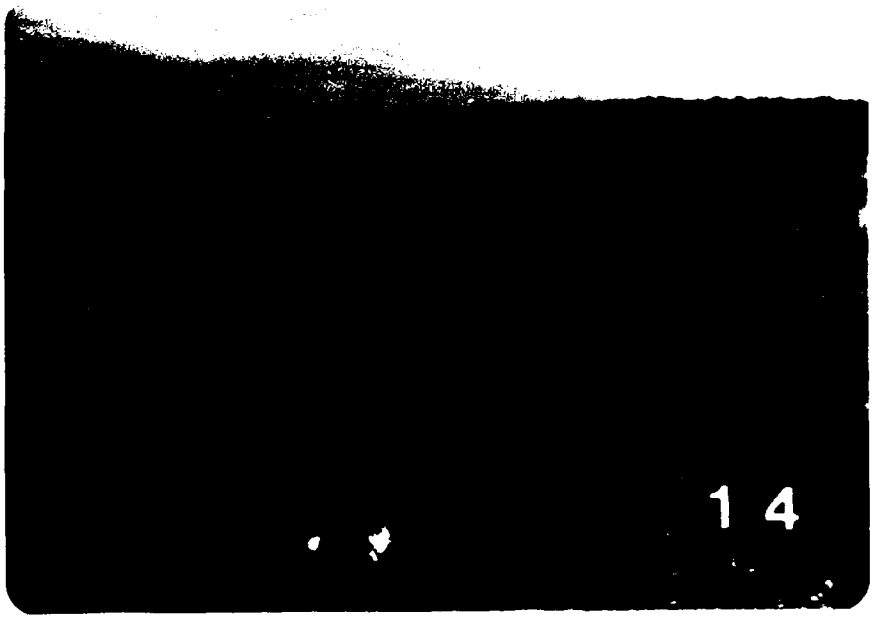
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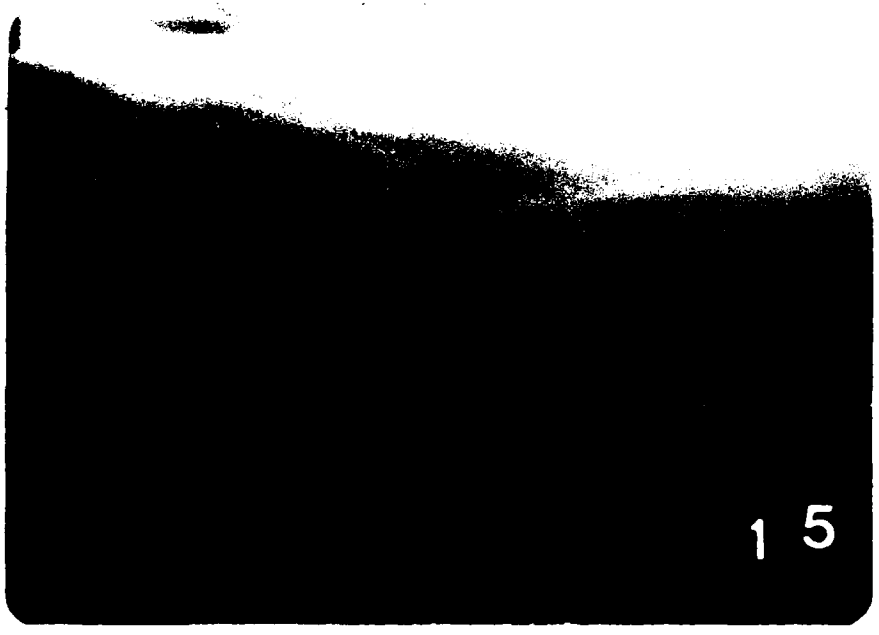
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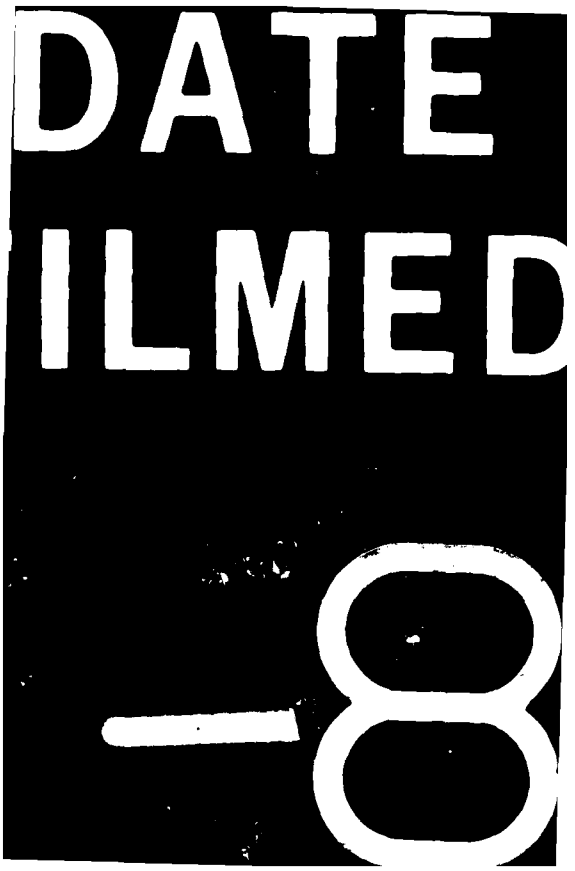
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